THE

ONTARIO WATER RESOURCES

COMMISSION

WATER POLLUTION SURVEY

of the

VILLAGE OF CHESTERVILLE

COUNTY OF DUNDAS

1972

THE

ONTARIO WATER RESOURCES

COMMISSION

REPORT ON A

WATER POLLUTION SURVEY

OF THE

VILLAGE OF CHESTERVILLE

IN THE

COUNTY OF DUNDAS

DIVISION OF SANITARY ENGINEERING

DISTRICT ENGINEERS BRANCH

1972

WATER POLLUTION SURVEY

OF THE

VILLAGE OF CHESTERVILLE

WATER POLLUTION SURVEY

VILLAGE OF CHESTERVILLE

INTRODUCTION

In 1965 a water pollution survey of the Village of Chesterville was performed to assess existing and potential sources of water pollution. A subsequent report directed recommendations to the municipality and to a local industry calling for the development of sewage treatment facilities.

The village's principal industry, Nestle (Canada) Limited, constructed an aerated lagoon in 1966 for the treatment of its wastes. In 1970, construction was completed on the joint OWRC/ Municipal sewage works project and sanitary wastes were directed to a waste stabilization pond from the village.

On September 22, 1971 investigations were made of water quality conditions in the South Nation River at Chesterville following the construction of the above-mentioned treatment facilities. The results of samples collected during this survey and in previous OWRC surveys have been summarized in the appendices to this report. A map of the Village of Chesterville showing sample point locations is also appended to the report.

The assistance provided by Mr. K.Graham, Reeve, and Mr. H. Sharkey, Village Superintendent, during this survey is gratefully acknowledged.

VILLAGE OF CHESTERVILLE

The Village of Chesterville which has been incorporated since 1890 is located on Highway 43 near the east boundary of the County of Dundas. The population of Chesterville is approximately 1,285 (1971 Municipal Directory)which is down slightly from the 1965 population.

SOUTH NATION RIVER

The South Nation River flows in an easterly direction through Chesterville. Drainage from the municipality is directed to the river by means of natural and improved drainage courses, and a storm sewer system. Previous OWRC surveys have revealed degradation of water quality in the South Nation River at Chesterville as a result of contaminated discharges from the above mentioned drainage system.

Flows in this area of the South Nation River vary considerably from the spring runoff peaks to mid summer lows. A summary of spot checks of summer flows for 1968 and 1969 at a gauging station on the South Nation River about 3.0 miles south-west of the Hamlet of South Mountain are as follows:

Year	Day	Flow (Cubic Feet per Second)
1968	July 2	207
	July 21	12.7
	August 4	7.4
	August 29	No flow (<0.1 cfs)
1969	May 29	79.8
	June 10	78.3
	June 24	492
	July 16	52.1
	July 29	49.8
	August 13	17.0

A control dam at Chesterville is operated by Nestle (Canada) Limited in order to ensure an adequate water supply for certain plant operations.

The new waste stabilization pond serving the municipality will be operated on a seasonal retention basis. The pond will be lowered in the spring during the period of high flow in the South Nation River. No discharge will normally be permitted from the pond during the summer months.

WATER SUPPLY

The Village of Chesterville has a municipal water works system which utilizes groundwater as the source of supply. One of the two drilled well supplies is maintained for standby purposes only. All water entering the system is provided chlorination disinfection. The average daily pumpage during 1971 approximated 67,000 gallons which corresponded to a per capita consumption of 52 gallons per person per day.

SEWAGE DISPOSAL

Prior to the construction of the municipal sewage works, private sewage disposal systems were employed for the treatment of domestic sewage. Previous OWRC inspections revealed that untreated or inadequately treated sewage wastes were often discharged to local storm sewers. Contaminated discharges from storm sewers and from private outfalls to the South Nation River were adversely affecting water quality.

The municipal sewage works includes a 14.5 acre waste stabilization pond in addition to associated collector sewers and a sewage pumping station. The municipal system was placed in operation on November 1, 1970. At the time of this survey 187 permits had been issued for connections to the sanitary sewers, of which some 165 connections had been completed. The original total number of service connections to be made in the serviced area

was 408. There has been some reluctance on the part of many property owners to connect to the sanitary sewers.

INDUSTRY

Nestle (Canada) Limited is Chesterville's principal industry and its products include powdered milk, puddings, instant coffee, instant chocolate drink and culinary sauces. The combined waste flow from this industry including process wastes, cooling water and sanitary sewage approximates 300,000 gallons per day. The process and sanitary wastes are directed to an aerated lagoon prior to discharge to the South Nation River. Liquid ammonia is added as a treatment aid and chlorination disinfection is provided. At the time this survey was conducted, problems were being experienced with the Nestle treatment system due to hydraulic overloading. The results of samples collected reflect the poor treatment being provided. The Division of Industrial Wastes of the OWRC has since been in contact with this industry and improved treatment has been effected.

SAMPLE RESULTS

Samples were collected for bacteriological examinations and chemical analyses from the South Nation River and from discharges to the river. The results of these samples together with the sample results from previous surveys are summarized in Appendix 1 of this report. A copy of the OWRC "Guidelines and Criteria for Water Quality Management in Ontario" has also been appended to the report.

In general, the results of this survey continue to reflect a high incidence of contaminated flows in the municipal storm sewers and associated drainage system. This is no doubt the result of failure by many property owners to connect to the sanitary sewers. There may also be some residual effect by old malfunctioning subsurface disposal systems.

As previously indicated, waste treatment problems had developed at Nestle (Canada) Limited at the time of this survey. The poor treatment of this industrial waste was reflected in the downstream quality in the South Nation River.

SUMMARY

A water pollution survey report on the Village of Chesterville in 1965 reviewed the need for improved sewage treatment facilities for the municipality and for Nestle (Canada) Limited. Subsequent to the above report treatment facilities were provided by the industry and later the municipality.

On September 22, 1971 investigations were made to assess water quality conditions in the South Nation River following the development of the municipal sewage works. Observations and sample results indicate that contaminated flows continue to be emitted from the municipal storm drainage system to the river. This has been attributed to the reluctance of many property owners to connect to the sanitary sewers. Although many properties have been connected to the sanitary sewers, it is considered that the remainder have been given ample opportunity to connect and should now be requested to do so. Failure to connect will result in the continued discharge of contaminated wastes into the South Nation River.

Waste treatment problems were being experienced at Nestle (Canada) Limited at the time of this survey and the effects of the inadequately treated wastes was evident in the downstream quality of the river. The OWRC has since been in contact with the industry and remedial action has been taken.

RECOMMENDATIONS

1) The Village of Chesterville should require that all properties in the sewered area be connected to the sanitary sewers by the end of 1972.

2) The Nestle (Canada) Limited plant should continue to effect waste treatment in accordance with the directions of the Division of Industrial Wastes of the Ontario Water Resources Commission.

REPORT PREPARED BY:

W C Stevens

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W. C. Stevens,
Technician
Div. of Sanitary Engineering.

WCS/lc

APPENDIX 1

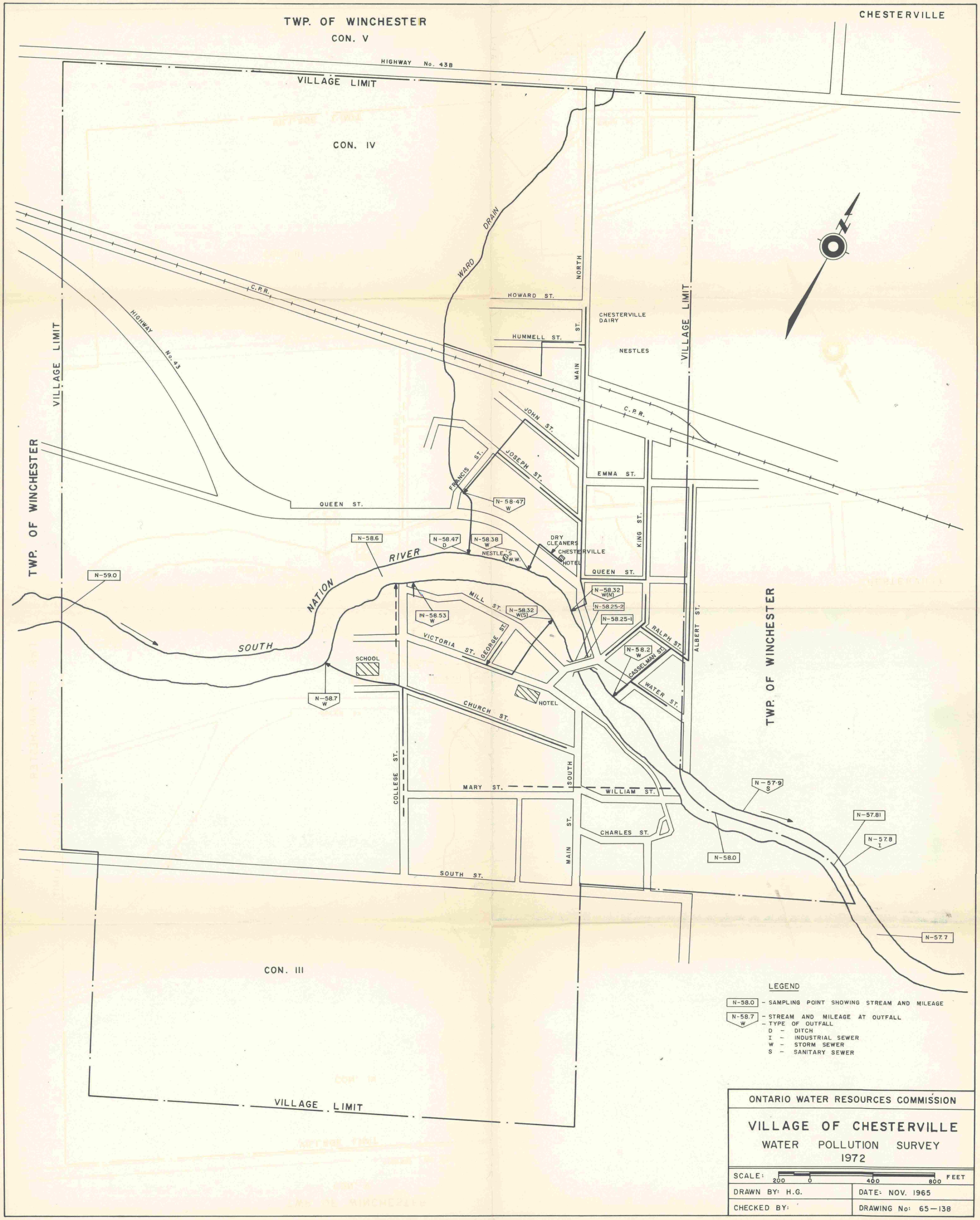
VILLAGE OF CHESTERVILLE

SAMPLE RESULTS

ple Point Number	Description of Sampling Point	Date	BACTERIOLOGICAL EXAMINATIONS: Coliform Bacteria	BACTERIOLOGICAL EXAMINATIONS: Fecal Coliforms	BACTERIOLOGICAL EXAMINATIONS: Fecal Streptococci	CHEMICAL ANALYSES: 5-Day BOD	CHEMICAL ANALYSES: Susp. Solids	CHEMICAL ANALYSES: Total Kjeldahl	CHEMICAL ANALYSES: Total Phos. as P
N-57.7	South Nation River-approx. 1[illegible]00 ft downstream from Nestle Milk plant waste outfall	May 9/62	57,000	-	-	38	-	-	-
		July27/65	114,000,000	-	-	290	109	-	-
		Aug 27/65	-	-	-	12	21	-	-
		Sept22/71	12,700	200	1,500	26	60	5.0	2.3
N-57.81	Industrial waste outfall from Nestle(Canada) Limited to South Nation River	May 9/62	45,000,000	-	-	145	94	-	-
		May13/65	-	-	-	404	636	-	-
		July27/65	460,000,000	-	-	550	664	-	-
		Sept22/71	1,100,000	67,000	80,000	240	440	32.0	14.0
N-57.81	South Nation River-150 ft upstream from Nestle waste outfall	May 9/62	227,000	-	-	1.4	-	-	-
		July27/65	120	-	-	1.2	4	-	-
		Sept22/71	1,600	10	10	1.0	5	1.0	0.14
N-57.9[illegible]	Sewage Pumping Station-bypass outfall	Sept22/71	no flow						
N-58.0	South Nation River at Chesterville dam	May 9/62	19,000	-	-	1.4	-	-	-
		Aug 2/62	2,900,000	-	-	-	-	-	-
		Oct 1/63	1,030	-	-	1.7	-	-	-
		Aug 11/64	9,000	-	-	1.7	2	-	-
		Dec 1/64	2,500	-	-	2.3	7	-	-
		July27/67	150	-	-	0.5	3	-	-
		Sept22/71	900	40	10	1.6	5	1.0	0.15
N-58.2W	Submerged storm sewer outfall to South Nation River-opposite Casselman St.	July27/65	4,600,000	-	-	-	-	-	-
		Sept22/71	430,000	4,000	390	10.0	35	6.5	3.9
N-58.25(1)	South Nation River at Hwy. 43 bridge -1/3 distance from N. Bank	May 9/62	600	-	-	1.6	-	-	-
		July27/65	480	-	-	0.8	5	-	-
		Sept22/71	890	40	10	1.2	5	0.98	0.14

APPENDIX 1 (Cont'd)

Sample Point Number	Description of Sampling Point	Date	BACTERIOLOGICAL EXAMINATIONS: Coliform Bacteria	BACTERIOLOGICAL EXAMINATIONS: Fecal Coliforms	BACTERIOLOGICAL EXAMINATIONS: Fecal Streptococci	CHEMICAL ANALYSES: 5-Day BOD	CHEMICAL ANALYSES: Susp. Solids	CHEMICAL ANALYSES: Total Kjeldahl	CHEMICAL ANALYSES: Total Phos. as P
N-58.25(2)	South Nation River at Hwy 43 bridge-1/3 distance from S. bank	May 9/62	194	-	-	1.4	-	-	-
		July27/65	16,900	-	-	2.0	5	-	-
N-58.32W(S)	Submerged storm sewer outfall to S. bank of river-400 ft west of Hwy 43 bridge	July27/65	-insufficient flow for sampling						
		Sept22/71	7300,000	10,000	100	-	-	-	-
N-58.32W(N)	Submerged storm sewer outfall to N. bank of river near intersection of Main & Queen Sts.	July27/65	53,000,000	-	-	130	99	-	-
		Sept22/71	-insufficient flow for sampling						
N-58.38W	Storm sewer outfall to river just west of Chesterville Hotel	July27/65	-insufficient flow for sampling						
		Sept22/71	1,500,000	300	15,000	28.0	30	8.5	2.3
N-58.47D	Collector ditch draining to river opposite Francis St.	July27/65	340,000,000	-	-	380.0	208	-	-
		Sept22/71	18,000	1,290	170	1.2	5	1.2	0.38
N-58.47W	Storm sewer outfall to Ward Drain at Francis St.	Sept22/71	15,300,000	2,000	13,800	-	-	-	-
N-58.53W	Sewer outfall to river at the foot of College St.	May 9/62	51,000,000						
		July27/65	-insufficient flow for sampling						
		Sept22/71	-insufficient flow for sampling						
N-58.7W	Storm sewer outfall to river west of the public school	July27/65	No Flow						
		Sept22/71	380,000	90,000	2,000	1.6	5	4.5	1.6
N-59.0	South Nation River at the western village limits-upstream from Chesterville	July27/65	32	-	-	0.8	5	-	-
		Sept22/71	6,000	10	10	1.6	5	1.1	0.054


CHESTERVILLE
TWP. OF WINCHESTER
CON. V
HIGHWAY No. 43B
VILLAGE LIMIT
CON. IV
C.P.R.
HIGHWAY No. 43
VILLAGE LIMIT
TWP. OF WINCHESTER
WARD DRAIN
NORTH
HOWARD ST.
ST.
CHESTERVILLE DAIRY
HUMMELL ST.
NESTLES
MAIN
VILLAGE LIMIT
C.P.R.
JOHN ST.
FRANCIS ST.
JOSEPH ST.
EMMA ST.
N-58.47 W
QUEEN ST.
KING ST.
N-58.6
N-58.47 D
N-58.38 W
NESTLE'S S.W.W.
DRY CLEANERS
CHESTERVILLE HOTEL
QUEEN ST.
N-59.0
RIVER
NATION
SOUTH
MILL ST.
N-58.53 W
N-58.32 W(S)
N-58.32 W(N)
N-58.25-2
N-58.25-1
RALPH ST.
ALBERT ST.
VICTORIA ST.
GEORGE ST.
N-58.2 W
CASSELMAN ST.
SCHOOL
HOTEL
WATER ST.
TWP. OF WINCHESTER
N-58.7 W
CHURCH ST.
COLLEGE ST.
SOUTH
MARY ST.
WILLIAM ST.
N-57.9 S
MAIN ST.
CHARLES ST.
N-57.81
N-57.8 I
N-58.0
SOUTH ST.
N-57.7
CON. III
VILLAGE LIMIT
LEGEND
N-58.0 - SAMPLING POINT SHOWING STREAM AND MILEAGE
N-58.7 W - STREAM AND MILEAGE AT OUTFALL
- TYPE OF OUTFALL
D - DITCH
I - INDUSTRIAL SEWER
W - STORM SEWER
S - SANITARY SEWER
ONTARIO WATER RESOURCES COMMISSION
VILLAGE OF CHESTERVILLE
WATER POLLUTION SURVEY
1972
SCALE: 200 0 400 800 FEET
DRAWN BY: H.G.
DATE: NOV. 1965
CHECKED BY:
DRAWING No: 65—138

Water management in Ontario

Ontario
Water Resources
Commission

June
1970

GUIDELINES and CRITERIA for WATER QUALITY MANAGEMENT in ONTARIO

GUIDELINES AND CRITERIA

FOR

WATER QUALITY MANAGEMENT IN ONTARIO

BY THE

ONTARIO WATER RESOURCES COMMISSION

HON. GEORGE A. KERR, Q.C.
Minister

J. H. H. ROOT, M.P.P.
Vice-Chairman

R. D. JOHNSTON
Chairman

135 St. Clair Avenue W., Toronto 7, Ontario
June, 1970

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INTRODUCTION

In 1967, the Ontario Water Resources Commission announced its Policy Guidelines for Water Quality Control in the Province of Ontario. This publication contains a re-statement of the guidelines and introduces water quality criteria for various uses including public, agricultural and industrial water supply, recreation, aesthetic enjoyment and the propagation of fish and wildlife. The use of water for assimilation and dilution of treated wastes must take into consideration these many desirable uses. Application of the criteria to water uses within the drainage basins of the province, or parts thereof, will lead to the development of water quality standards for the control of water pollution.

GUIDELINES FOR THE CONTROL OF WATER QUALITY

1 The water resources of Ontario must meet many needs, some of which are in conflict. The standards established, therefore, must be based on the best interests of the people of Ontario. These interests require the preservation, and restoration where necessary, of the quality of our water for the greatest number of uses. The use of water for the assimilation and dilution of treated waste effluents must take into consideration the variety of uses, including public, agricultural and industrial supply, recreation, aesthetic enjoyment and the propagation of fish and wildlife.

2 For each use of water there are certain water quality characteristics, identified as criteria, which should be met to ensure that the water is suitable for that use.

3 Water quality standards will be established by the Ontario Water Resources Commission for waters of drainage basins or parts thereof with important water uses, following consultation with agencies or persons having an interest or responsibility in the present or future use of the water in the basin for which the standards are to be established.

4 Water of a higher quality than that required by the standards will be maintained at that higher quality unless in the public interest an alteration of the quality is consistent with the protection of all uses which are in accordance with the water quality standards established.

There should be a constant effort to improve the quality of water, for it is recognized that the improvement of the quality of water makes it available for more uses.

5 Requirements for effluents and land drainage based on the applicable water quality standards, or criteria where such standards do not exist, will be established by the Commission in order to maintain acceptable water quality. More stringent methods of control and/or treatment of waste inputs and land drainage may become necessary as the use of water changes or increases, or as standards are re-defined.

6 In establishing effluent requirements from water quality standards a reserve capacity of the receiving water should be set aside to provide an adequate margin of protection in recognition of the limitations of water management theory and practice.

7 All wastes prior to discharge to any receiving watercourse must receive the best practicable treatment or control. Such treatment must be adequate to protect and wherever possible upgrade water quality in the face of population and industrial growth, urbanization and technological change.

8 Criteria and standards of water quality and effluent requirements will be defined quantitatively only where sound numerical information is available; otherwise, they will be described in appropriate detail. They will be re-defined from time to time in the light of new evidence.

WATER QUALITY CRITERIA

The following criteria for water quality are a set of numerical and descriptive characteristics, carefully defined, and applicable to each major water use category such as agriculture; fish, other aquatic life and wildlife; industrial water supply; public water supply; recreation and aesthetics. The criteria are described for use in establishing Water Quality Standards for drainage basins which in turn will be used to determine Effluent Requirements for discharges of wastes and land drainage.

The responsibility for demonstrating that a waste effluent is harmless to water uses in the concentrations to be found in the receiving waters, rests with those producing the discharge. Zones of passage and/or mixing adjacent to outfalls at the limit of which water quality may be critical, will be prescribed by the Commission.

Reference is frequently made in the Criteria to the Report of the Committee on Water Quality, Federal Water Pollution Control Administration, U.S. Department of the Interior (1968). Acknowledgement of the report is gratefully given in recognition of its basic reference value.

ZONES OF PASSAGE AND MIXING

Mixing zones in the vicinity of outfalls should be restricted as much as possible in extent and should provide for the safe passage of both fish and free-floating and drift organisms. Every precaution should be taken to ensure that at least two-thirds of the total cross-sectional area of a river or stream is characterized by a quality which is entirely favourable to the aquatic community at all times. In most cases this would preclude the use of a diffuser outfall which would distribute effluent uniformly across the river or stream. The water quality standard which defines the acceptable concentration of a substance contained in a waste discharge will apply at the periphery of the mixing zone or other specified sampling location.

Within mixing zones, it should be recognized that toxic wastes which will not evoke an avoidance response on the part of fish or other organisms should not be permitted. Where toxic materials are being discharged it should be assumed that the various components in the waste, regardless of the form in which they are present, may eventually be altered to the most toxic form in the aquatic environment. Adequate treatment of all wastes should be provided and mixing zones should not be considered as a substitute for proper treatment.

STATISTICAL PROBLEMS IN SETTING LIMITS

The systematic surveillance of water and waste sources requires the collection of data to clearly represent the problems being studied. The problems are many and varied. In one case the average condition over a period of time may be required and the question arises over what period shall the average or median be taken; in another, the limit may be a figure that should not be exceeded at any time. If a standard for a certain constituent is "none", the question arises "how small an amount does this mean?" The answers vary with the type of standard and the circumstances governing the fluctuation of the indicator. In ground water problems, only the average over a considerable period of time is significant. Where required in the setting of standards and effluent requirements, definitions of limits will include the applicable sampling conditions, quantitative values and rates of discharge.

1 WATER QUALITY CRITERIA FOR AGRICULTURAL USES (AGR)

Agricultural production requires water of suitable quality for a variety of uses. Criteria for the major uses are given under three headings: Dairy Sanitation, Livestock Watering, and Irrigation.

Requirements for domestic and other farmstead uses and the common requirements for dairy sanitation are given elsewhere in the criteria for Private Water Supplies and Public Water Supplies.

AGR-1 Dairy Sanitation

Modern methods for bulk handling of milk on farms require large volumes of good quality water to ensure a premium product. The quality of water needed for good dairy sanitation requires criteria for certain parameters that are additional to, or more stringent than, those required for private water supplies. These are summarized under the headings "Permissible Criteria" and "Desirable Criteria". They should be used in conjunction with the criteria for public and private water supplies.

Treatment may prove satisfactory in meeting the criteria for certain of the inorganic chemicals such as iron and total hardness.

Waters that meet the desirable microbiological criteria can be used without disinfection; those meeting the permissible criteria require disinfection (chlorination), or chlorination and filtration, before use to reduce bacteria to levels where they will not cause deterioration of the quality of milk. Waters used for dairy sanitation should be sampled and tested at least monthly, in some cases daily, to ensure that they meet the microbiological criteria.

TABLE AGR-1

Water Quality Criteria for Agricultural Uses
Dairy Sanitation

Constituent or Characteristic	Permissible Criteria	Desirable Criteria
Inorganic Chemicals:		
Copper	0.1 mg/l	
Iron	0.1 mg/l	
pH (range)	6.8 to 8.5	
Potassium	20 mg/l	
Total hardness as $CaCO_3$	150 mg/l	100 mg/l
Microbiological:		
Proteolytic and/or Lipolytic bacteria (20°C) (individual results)	500/100 ml	0/100 ml
Yeast		Absent
Mould		Absent
Physical:		Clear Colourless Good taste

AGR-2 Livestock Watering

The health and productivity of livestock are affected by the quantities of various substances ingested as feed and as water. Accordingly, the amounts of certain substances that can be present without harm in water consumed by livestock will depend in part on the amounts of the same substances that are present in the feed in addition to a number of other factors which include: the daily water requirements and the species, age, and physiological condition of the animals, and the nature and quantities of other constituents of the feed and water.

Animals may be able to tolerate a fairly high level of total dissolved solids or bacteria if they are accustomed to such levels, but may be unable to tolerate a sudden change from waters with low dissolved solids or bacteria to waters with high dissolved solids or bacteria.

In addition to direct effects on the animals, certain substances may contaminate animal products to the point where they will not be acceptable for human consumption.

The variability of the factors that influence the acceptability of water for livestock-watering purposes must be considered when using the water quality criteria. Although the criteria provide a general guide to the quality of water that will be acceptable for most livestock, there may be cases where water of different quality than that indicated by the criteria will be required or acceptable because of the nature, age, or condition of species being raised or because of special rearing conditions or feed components. In such cases, or where the quality of an individual supply is in doubt, the quality should be assessed in relation to the specific use.

Water meeting the permissible criteria will be satisfactory for most livestock under normal rearing conditions. Water meeting the desirable criteria should provide a palatable and safe source for all normal livestock-watering purposes.

TABLE AGR-2
Water Quality Criteria for Agricultural Uses
Livestock

Constituent or Characteristic	Permissible Criteria	Desirable Criteria
General Quality		ideally should meet the desirable criteria for private water supplies.
Inorganic Chemicals:		
Total Dissolved Solids	2500 mg/l	< 500 mg/l
Arsenic	0.05 mg/l	Absent
Cadmium	0.01 mg/l	Absent
Chromium (hexavalent)	0.05 mg/l	Absent
Fluoride	2.4 mg/l	1.2 mg/l
Lead	0.05 mg/l	Absent
Nitrate plus Nitrite (as N)	20 mg/l	< 10 mg/l
Selenium	0.01 mg/l	Absent
Sulphate	1000 mg/l	< 250 mg/l
Radioactivity:		
Radium-226	3 pc/l	< 1 pc/l
Strontium-90	10 pc/l	< 2 pc/l
Gross beta activity in the known absence of strontium-90 and alpha-emitting radionuclides.	1000 pc/l	< 100 pc/l
Microbiological: (1)		
Enterococci (35°C)	< 40/100 ml	0/100 ml
Algae	No heavy growth of blue-green algae	

(1) The supply should be free of barnyard runoff and of effluent contamination from either man or animals. The geometric mean of sample results should not exceed the values given.

AGR-3 Irrigation

The suitability of water for irrigation cannot be defined precisely because the effects of the water on the crop being irrigated depend on many factors. These include: soil types, climatic conditions, irrigation practices, variations in the relation between the concentration and composition of the irrigation water and the soil solution, variations in the tolerance of different plants to the combined or individual constituents in the irrigation water or the soil solution, and the modifying effects of interrelations between and among the constituents. In general, for satisfactory irrigation, soils with poor drainage characteristics require water of higher quality than better drained soils.

In humid areas, excessive concentrations of salts or individual elements will normally be leached from the soil during periods of heavy rainfall or snowmelt before or after the growing season. This leaching action is another factor affecting the quality of water that can be used for irrigation. It may allow the use of water of poorer quality than that listed in these criteria for some crops and conditions without serious detrimental effects. Also through proper timing and adjustment of frequency and volumes of water applied, detrimental effects of poorer quality water may often be mitigated. Good drainage of soil may be a factor of similar importance as the quality of the water used.

The presence of sediment, pesticides, or pathogenic organisms in irrigation water, which may not specifically affect plant growth, may affect the acceptability of the product. Larger sediment particles could lead to plugging of sprinkler nozzles.

Although there are many variations in the quality of water that is suitable for specific irrigation uses, water quality criteria have been assembled as a guide to the quality of water that will meet many irrigation needs. The criteria are listed as permissible and desirable. Water meeting the desirable criteria should be satisfactory for irrigation of most crops in most soil types for long periods of time. Water meeting the permissible criteria, while suitable for many crops, soil and climatic conditions, could result in decreased yields for some crops if it is used repeatedly, unless there is dilution or leaching by precipitation or the application of excess irrigation water under favourable drainage conditions. Special crops or conditions, such as the growing of plants in greenhouses, may require irrigation with water of higher quality than that indicated by the desirable criteria.

The suitability of a given source of water for specific crops, soil types, and climatic conditions should be judged on an individual basis if its suitability has not been demonstrated by practice.

TABLE AGR-3

Water Quality Criteria for Agricultural Uses

Irrigation

Constituent or Characteristic	Permissible Criteria	Desirable Criteria
Physical:		
Temperature		55°F to 85°F
Microbiological: (1)		
Fecal Coliforms (44.5°C)	100/100 ml	0/100 ml
Enterococci (35°C)	20/100 ml	0/100 ml
Total bacteria (20°C)	100,000/100 ml	< 10,000/100 ml
Inorganic Chemicals:		
Aluminum	20.0 mg/l	< 1.0 mg/l
Arsenic	10.0 mg/l	< 1.0 mg/l
Beryllium	1.0 mg/l	< 0.5 mg/l
Boron	0.5 mg/l	0.3 mg/l
Cadmium	0.05 mg/l	< 0.005 mg/l
Chloride	150 mg/l	< 70 mg/l
Chloride—special requirement for tobacco	70 mg/l	< 20 mg/l
Chromium	20.0 mg/l	< 5.0 mg/l
Cobalt	10.0 mg/l	< 0.2 mg/l
Copper	5.0 mg/l	< 0.2 mg/l
Lead	20.0 mg/l	< 5.0 mg/l
Lithium	5.0 mg/l	< 5.0 mg/l
Manganese	20.0 mg/l	< 2.0 mg/l
Molybdenum	0.05 mg/l	< 0.005 mg/l
Nickel	2.0 mg/l	< 0.5 mg/l
pH (range)	4.8 to 9.0	
Residual Sodium Carbonate $=(CO_3^{--}+HCO_3^{-})-(Ca^{++}+Mg^{++})$ expressed as mg eq/l	1.25 mg eq/l	< 1.25 mg eq/l
Selenium	0.05 mg/l	< 0.05 mg/l
Sodium Adsorption Ratio $=\dfrac{Na^{+}}{\sqrt{\dfrac{Ca^{++}+Mg^{++}}{2}}}$ expressed as mg eq/l	6	< 4
Total dissolved solids		
Vanadium	500 mg/l	< 200 mg/l
Zinc	10.0 mg/l	< 10.0 mg/l
	5.0 mg/l	< 5.0 mg/l
Organic Chemicals:		
Pesticides	Insecticides, herbicides, fungicides, and rodenticides must not be present in waters used for irrigation in concentrations that are detrimental to crops, livestock, wildlife or man.	Absent

(1) The geometric mean of sample results should not exceed the values given.

2 WATER QUALITY CRITERIA FOR THE PROTECTION OF FISH, OTHER AQUATIC LIFE AND WILDLIFE (F & W)

The following criteria are considered to be satisfactory for fish, other aquatic life and wildlife. Reference is made to aspects of water quality considered to be most important in the light of current knowledge. Narrative guidelines are offered where quantification is not yet possible.

Dissolved Materials

Dissolved materials should not be added to increase the concentration of dissolved solids by more than one-third of the natural condition of the receiving water, owing to potentially harmful osmotic effects of high concentrations. Dissolved materials that are harmful in relatively low concentrations are discussed in the section "Toxic Substances".

pH, Alkalinity, Acidity

(1) pH should be maintained within a range of 6.5 to 8.5.

(2) To protect the carbonate system, and thus the productivity of the water, acid should not be added in sufficient quantity to lower the total alkalinity to less than 20 mg/l.

Temperature

(1) **General**

Unless a special study shows that discharge of a heated effluent into the hypolimnion of a lake will be desirable, such practice is not recommended and water for cooling should not be pumped from the hypolimnion to be discharged to the same body of water.

The normal daily and seasonal temperature variations that were present before the addition of heat due to other than natural causes should be maintained.

Wherever possible, heated discharges should be located where elevated temperature will enhance public utilization of the water by supporting a wider variety of water uses.

(2) **Great Lakes and Connecting Waters**

(a) Heated discharges are not permitted that may stimulate production of nuisance organisms or vegetation or that are or may become injurious to wildlife, waterfowl, fish or other aquatic life or the growth and reproduction thereof. For each discharge of a heated effluent, acceptable mixing zones will be established on the basis of features and facts pertinent to that specific situation.

(b) Heat may not be discharged in the vicinity of spawning areas or where increased water temperature might interfere with recognized movements of spawning or migrating fish populations.

(3) **Inland Waters**

(a) Heated discharges to inland waters will not be permitted unless it is clearly demonstrated that heated effluents will enhance the usefulness of the water resource without endangering the production and optimum maintenance of wildlife, fish and other aquatic species. It shall be the responsibility of the user to provide evidence to support the acceptability of the discharge under these terms.

(b) Inland trout streams, salmon streams, trout and salmon lakes and the hypolimnion of lakes and reservoirs containing salmonids and other cold water forms should not be warmed.

(c) Heat may not be discharged in the vicinity of spawning areas or where increased temperature might interfere with recognized movements of spawning or migrating fish populations.

Dissolved Oxygen

(1) **Warm-water Biota**

The dissolved oxygen (DO) concentration should be above 5 mg/l at all times, except that in certain situations concentrations may range between 5 and 4 mg/l for short intervals within any 24-hour period provided that water quality is favourable in all other respects.

(2) **Cold-water Biota**

In spawning areas, DO levels must not be below 7 mg/l at any time. Elsewhere, DO concentrations should not be below 6 mg/l. In certain situations, they may range between 6 and 5 mg/l for short intervals within any 24-hour period, provided the water quality is favourable in all other respects.

Carbon Dioxide

The 'free' carbon dioxide concentration should not exceed 25 mg/l.

Oil

Oil, petrochemicals or other immiscible substances that will cause visible films or toxic, noxious or nuisance conditions should not be added to water.

Turbidity

(1) Turbidity associated with waste inputs should not exceed 50 Jackson units in warm-water streams or 10 Jackson units in cold-water streams.

(2) There should be no discharge which would cause turbidities exceeding 25 Jackson units in warm-water lakes or 10 Jackson units in cold-water or oligotrophic lakes.

Settleable Materials

Substances should not be added that will adversely affect the aquatic biota or will create objectionable deposits on the bottom or shore of any body of water.

Colour and Transparency

For effective photosynthetic production of oxygen, it is required that 10 per cent of the incident light reach the bottom of any desired photosynthetic zone in which adequate dissolved oxygen concentrations are to be maintained.

Floating Materials

All floating materials, other than those of natural origin, should be excluded from streams and lakes.

Tainting substances

All materials that will impart odour or taste to fish or edible invertebrates should be excluded from receiving waters at levels that produce tainting.

Radionuclides

Radioactive materials should not be present in natural waters as a consequence of failure to exercise necessary controls of radioactivity releases to keep exposure to a minimum.

Experience has shown that standards established for drinking water assure that people will receive no more than currently acceptable amounts of radioactive materials from aquatic sources and that fish and other aquatic life will not receive an injurious dose of radiation.

Thus, present standards accepted for the protection of fish and other aquatic life are as follows:

	pc/l
Gross beta emitters	1000
Radium-226	3
Strontium-90	10

Where other radioisotopes occur, the significance of the exposure of aquatic species to these forms of radiation should be assessed for each situation, both with respect to potential damage to the organisms themselves and to humans where fish or other edible forms are utilized.

Plant Nutrients and Nuisance Growths

(1) Nutrients from unnatural sources that will stimulate production of algae, nuisance vegetation or offensive slime growths should not be added to water. The addition of sulphates or manganese oxide to a lake should be limited if iron is present in the hypolimnion as these substances may increase the quantity of available phosphorus.

(2) Organic or other materials that will promote an increased zone of anaerobic decomposition within a lake, reservoir or other body of water should not be allowed to enter the water.

(3) The naturally-occurring ratios of nitrogen (particularly NO_3 and NH_4) to total phosphorus, and their amounts, should not be radically changed by the addition of materials from waste sources and land drainage.

Toxic Substances

Toxic substances must not be added to water in concentrations or combinations that are toxic or harmful to human, animal, plant or aquatic life, except where the application of approved substances for the control of nuisance organisms has been authorized by the Commission (Section 28b, OWRC Act).

The evaluation of toxicity for aquatic organisms is based on use of the TLm or median tolerance limit. This represents the concentration at which half the test organisms will succumb over a given period of exposure such as 24, 48 or 96 hours. It does not, therefore, represent the safe concentration and an application factor is applied to ensure a safe condition, including allowance for sub-lethal effects.

(1) **Substances of Unknown Toxicity**

All effluents containing foreign materials should be considered harmful and not permissible until bioassay tests have shown otherwise. The onus for demonstrating that an effluent is harmless in the concentrations to be found in the receiving waters rests with those responsible for the discharge. Information concerning acceptable bioassay procedures is available from the Commission.

(2) **Application Factors**

Concentration of materials that are non-persistent (that is, have a half-life of less than 96 hours), or have non-cumulative effects after mixing with the receiving waters, should not exceed 1/10 of the applicable 96-hour TLm value at any time or place based on species representative of local conditions. The 24-hour average of the concentration of these materials should not exceed 1/20 of the TLm value after mixing. For other toxicants, the concentrations should not exceed 1/20 and 1/100 of the TLm value under the aforementioned conditions.

(3) **Additive Effects**

When two or more toxic materials that have additive effects are present at the same time in the receiving water, some reduction is necessary in the permissible concentrations as derived from bioassays on individual substances or wastes. The amount of reduction required is a function of both the number of toxic materials present and their concentrations in respect to the derived permissible concentration. An appropriate means of assuring that the combined

amounts of the several substances do not exceed a permissible concentration for the mixture is through the use of the following relationship:

$$\left(\frac{C_a}{L_a} + \frac{C_b}{L_b} \ldots + \frac{C_n}{L_n} \leq 1\right)$$

where C_a, C_b,.......C_n are the measured concentrations of the several toxic materials in the water and L_a, L_b, ... L_n are the respective permissible concentration limits derived for the materials on an individual basis. Should the sum of the several fractions exceed one, then a local restriction on the concentration of one or more of the substances is necessary.

(4) **Pesticides**

(a) Chlorinated Hydrocarbons:

Any addition of chlorinated hydrocarbon insecticides is likely to cause damage to some desired organisms and their use should be avoided.

(b) Other Chemical Pesticides:

Other pesticides and herbicides gaining access to water can cause damage to desirable organisms and should be used with utmost discretion and caution. Tables F & W-1 and F & W-2 list the 48-hour TLm values of a number of pesticides for various types of fresh water organisms. To provide reasonably safe concentrations of these materials in receiving waters, application factors ranging from 1/10 to 1/100 should be used, with these values depending on the characteristic of the pesticide in question and used as specified in (2) above. Concentrations thus derived may be considered tentatively safe under the conditions specified. TLm values and related application factors are subject to revision as additional bioassay information is obtained for species which may be more representative of local conditions.

(5) **Other Toxic Substances**

(a) ABS: The concentration of ABS should not exceed 1/7 of the 48-hour TLm at any time or place.

(b) LAS: The concentration of LAS should not exceed 1/7 of the 48-hour TLm at any time or place.

(c) ARSENIC: An application factor of 1/100 should be applied to the 96-hour TLm value as a tentative safe concentration for continuous exposure. An environmental level of .01 mg/l should not be exceeded under any circumstances.

(d) AMMONIA: Permissible concentrations of ammonia should be determined by the flow-through bioassay with the pH of the test solution maintained at 8.5, DO concentrations between 4 and 5 mg/l, and temperatures near the upper allowable levels.

(e) CADMIUM: The concentration of cadmium must not exceed 1/500 of the 96-hour TLm concentration at any time or place.

(f) CHROMIUM: The concentration of chromium should not exceed 1/100 of the 96-hour TLm at any time or place.

(g) COPPER: The maximum copper (expressed as Cu) concentration at any time or place shall not be greater than 1/12 of the 96-hour TLm value. The maximum permissible concentration for continuous exposure is between 3 per cent and 7 per cent of the 96-hour TLm.

(h) LEAD: The concentration of lead should not exceed 1/20 of the 96-hour TLm at any time or place and the 24-hour average should not exceed 1/100 of the 96-hour TLm concentration after mixing.

(i) MERCURY: Owing to demonstrated cumulative effects of mercury in fish, and the attendant hazard to other animals, discharges of mercury to water should be avoided.

(j) NICKEL: The concentration of nickel should not exceed 1/50 of the 96-hour TLm concentration at any time or place.

(k) ZINC: The concentration of zinc should not exceed 1/100 of the 96-hour TLm concentration at any time or place.

TABLE F & W-1 INSECTICIDES*

(48-hour TLm values from static bioassay, in micrograms per litre. Exceptions are noted.)

Pesticide	Stream Invertebrate[1] Species	Stream Invertebrate[1] TLm	Cladocerans[2] Species	Cladocerans[2] TLm	Fish[3] Species	Fish[3] TLm	Gammarus Lacustris,[4] TLm
Abate	Pteronarcys californica	100			Brook trout	1,500	640
Aldrin[5]	P. californica	8	Daphnia pulex.	28	Rainbow trout	3	12,000
Allethrin	P. californica	28	D. pulex	21	- do -	19	20
Azodrin					- do -	7,000	
Aramite			D. magna	345	Bluegill	35	100
Baygon[5]	P. californica	110			Fathead	25	50
Baytex[5]	P. californica	130	Simocephalus serrulatus	3.1	Brown t.	80	70
Benzene hexachloride (lindane)	P. californica	8	D. pulex	460	Rainbow t.	18	88
Bidrin	P. californica	1900	D. pulex	600	- do -	8,000	790
Carbaryl (sevin)	P. californica	1.3	D. pulex	6.4	Brown t.	1,500	22
Carbophenothion (trithion)			D. magna	0.009	Bluegill	225	28
Chlordane[5]	P. californica	55	S. serrulatus	20	Rainbow t.	10	80
Chlorobenzilate			S. serrulatus	550	- do -	710	
Chlorthion			D. magna	4.5			
Coumaphos			D. magna	1			0.14
Cryolite			D. pulex	5,000	Rainbow t.	47,000	
Cyclethrin			D. magna	55			
DDD (TDE)[5]	P. californica	1100	D. pulex	3.2	Rainbow t.	9	1.8
DDT[5]	P. californica	19	D. pulex	0.36	Bass	2.1	2.1
Delnav (dioxathion)					Bluegill	14	690
Delmeton (systex)				14	- do -	81	
Diazinon[5]	P. californica	60	D. pulex	0.9	- do -	30	500
Dibrom (naled)	P. californica	16	D. pulex	3.5	Brook t.	78	160
Dieldrin[5]	P. californica	1.3	D. pulex	240	Bluegill	3.4	1,000
Dilan			D. magna	21	- do -	16	600
Dimethoate (cygon)	P. californica	140	D. magna	2500	- do -	9600	400
Dimethrin					Rainbow t.	700	
Dichlorvos[5] (DDVP)	P. californica	10	D. pulex	0.07	Bluegill	700	1
Disulfoten (di-syston)	P. californica	18			- do -	40	70

* From Report of the Committee on Water Quality Criteria, Federal Water Pollution Control Administration, U.S. Department of the Interior (1968).

TABLE F & W-1—continued

Pesticide	Stream Invertebrate[1] Species	TLm	Cladocerans[2] Species	TLm	Fish[3] Species	TLm	Gammarus Lacustris,[4] TLm
Dursban	Peteronareella badia	1.8			Rainbow t.	20	0.4
Endosulfan (thiodan)	P. californica	5.6	D. magna	240	- do -	1.2	64
Endrin[5]	P. californica	0.8	D. pulex	20	Bluegill	0.2	4.7
EPH			D. magna	0.1	- do -	17	36
Ethion	P. californica	14	D. magna	0.01	- do -	230	3.2
Ethyl guthion[5]			D. pulex		Rainbow t.		
Fenthion	P. californica	39	D. pulex	4			
Guthion[5]	P. californica	8	D. magna	0.2	Rainbow t.	10	0.3
Heptachlor[5]	P. badia	4	D. pulex	42	- do -	9	100
Kelthane (dicofel)	P. californica	3000	D. magna	390	- do -	100	
Kepone					- do -	37.5	
Malathion[5]	P. badia	6	D. pulex	1.8	Brook t.	19.5	1.8
Methoxychlor[5]	P. californica	8	D. pulex	0.8	Rainbow t.	7.2	1.3
Methyl parathion[5]			D. magna	4.8	Bluegill	8000	
Morestan	P. californica	40			- do -	96	
Ovex	P. californica	1500			- do -	700	
Paradichlorobenzene					Rainbow t.	880	
Parathion[5]	P. californica	11	D. pulex	0.4	Bluegill	47	6
Perthane			D. magna	9.4	Rainbow t.	7	
Phosdrin[5]	P. californica	9	D. pulex	0.16	- do -	17	310
Phosphamidon	P. californica	460	D. magna	4	- do -	8000	3.8
Pyrethrins	P. californica	64	D. pulex	25	- do -	54	18
Rotenone	P. californica	900	D. pulex	10	Bluegill	22	350
Strobane[5]	P. californica	7			Rainbow t.	2.5	
Tetradifon (tedion)					Bluegill	1100	140
TEPP[5]					Fathead	390	52
Thanite			D. magna	450			
Thimet					Bluegill	5.5	70
Toxaphene[5]	P. californica	7	D. pulex	15	Rainbow t.	2.8	70
Trichlorofon (dipterex)[5]	P. badia	22	D. magna	8.1	- do -	160	60
Zectran	P. californica	16	D. pulex	10	- do -	8000	76

TABLE F & W-2

HERBICIDES, FUNGICIDES, DEFOLIANTS, ALGICIDES*

Pesticide	Stream Invertebrate[1] Species	Stream Invertebrate[1] TLm	Cladocerans[2] Species	Cladocerans[2] TLm	Fish[3] Species	Fish[3] TLm	Gammarus Lacustris,[4] TLm
Ametryne					Rainbow t.	3400	
Aminotriazole							
Aquathol					Bluegill	257	
Atrazine			Daphnia magna	3600	Rainbow t.	12,600	
Azide, potassium					Bluegill	1400	10,000
Azide, sodium					- do -	980	9000
Copper chloride					- do -	1100	
Copper sulphate					- do -	150	
Dichlobenil	Pteronarcys californica	44,000	Daphnia pulex	3700	- do -	20,000	1500
2,4-D PGBEE			D. pulex	3200	Rainbow t.	960	1800
2,4-D BEE	P. californica	1800			Bluegill	2100	760
2,4-D isopropyl					- do -	800	
2,4-D butyl ester					- do -	1300	
2,4-D butyl + isopropyl ester					- do -	1500	
2,4,5-T isooctyl ester					- do -	16,700	
2,4,5-T isopropyl ester					- do -	1700	
2,4,5-T PGBE					- do -	560	
2(2,4-DP) BEE					- do -	1100	
Dalapon	P. californica Very low toxicity		D. magna	6000		Very Low Toxicity	
Dead-X	P. californica	5000	D. pulex	3700	Rainbow t.	9400	5600
DEF	P. californica	2300			Bluegill	36	230
Dexon	P. californica	42,000			Bluegill	23,000	6000
Dicamba					non-toxic		5800
Dichlone			D. magna	26	Rainbow t.	48	11,500
Difolitan	P. californica	150			Channel Cat	31	6500
Dinitrocresol	P. californica	560			Rainbow t.	210	
Diquat					Rainbow t.	12,300	
Diuron	P. californica	2800	D. pulex	1400	- do -	4300	380
Du-ter					Bluegill	33	
Dyrene			D. magna	490		15	
Endothal, copper					Rainbow t.	290	

* From Report of the Committee on Water Quality Criteria, Federal Water Pollution Control Administration, U.S. Department of the Interior (1968).

TABLE F & W-2—continued

Pesticide	Stream Invertebrate[1] Species	Stream Invertebrate[1] TLm	Cladocerans[2] Species	Cladocerans[2] TLm	Fish[3] Species	Fish[3] TLm	Gammarus Lacustris,[4] TLm
Endothal dimethylamine					Rainbow t.	1150	
Fenac, acid	P. californica	70,000			- do -	16,500	
Fenac, sodium	P. californica	80,000	D. pulex	4500	- do -	7500	18,000
Hydram (molinate)	P. californica	3500			- do -	290	
Hydrothol 191					- do -	690	1000
Lanstan (Korax)					- do -	100	5500
LFN					- do -	79	
Paraquat	P. californica Very low toxicity		D. pulex	3700	Very low toxicity		18,000
Propazine					Rainbow t.	7800	
Silvex, PGBEE			D. pulex	2000	- do -	650	
Silvex, isoctyl					Bluegill	1400	
Silvex, BEE					- do -	1200	
Simazine	P. californica	50,000			Rainbow t.	5000	21,000
Sodium arsenite	P. californica Very low toxicity		Simocephalus serrulatus	1400	- do -	36,500	
Tordon (picloram)					- do -	2500	48,000
Trifuralin	P. californica	4200	D. pulex	240	- do -	11	5600
Vernam[5] (vernolate)					- do -	5900	25,000

1 Stonefly bioassay was done at Denver, Colo., and at Salt Lake City, Utah. Denver tests were in soft water (35 mg/l TDS), non-aerated, 60 F. Salt Lake City tests were in hard water (150 mg/l TDS), aerated, 48-50 F. Response was death.

2 Daphnia pulex and Simocephalus serrulatus bioassay was done at Denver, Colo., in soft water (35 mg/l TDS), non-aerated, 60 F. Daphnia magna bioassay was done at Pennsylvania State University in hard water (146 mg/l TDS), non-aerated, 68 F. Respone was immobilization.

3 Fish bioassay was done at Denver, Colo., and at Rome N.Y. Denver tests were with 2-inch fish in soft water (35 mg/l TDS), non-aerated, trout at 55 F.; other species at 65 F. Rome tests were with 2-2½ inch fish in soft water (6 mg/l TA: pH 5.85-6.4), 60 F. Response was death.

4 Gammarus bioassay was done at Denver, Colo., in soft water (35 mg/l TDS), non-aerated, 60 F. Response was death.

5 Becomes bound to soil when used according to directions, but highly toxic (reflected in numbers) when added directly to water.

3 WATER QUALITY CRITERIA FOR INDUSTRIAL WATER SUPPLIES (IWS)

Desired water quality criteria are tabled for the major industrial classifications as follows:

Brewing and Soft Drinks	— IWS-1
Chemical and Allied Products	— IWS-2
Industrial Cooling	— IWS-3
Food Processing	— IWS-4
Electroplating and Metal Finishing	— IWS-5
Iron and Steel	— IWS-6
Petroleum	— IWS-7
Pulp and Paper	— IWS-8
Leather Tanning and Finishing	— IWS-9
Textiles	— IWS-10

While the values listed should not normally be exceeded, these water quality criteria can vary considerably for the same industrial process depending on factors such as the technological age of plant design.

A raw surface water and/or ground water supply which is used by many different industries may not satisfy the widely varying criteria for each use. However, water treatment technology in its present state of development permits the utilization of surface water of literally any available quality to produce water of any desired quality at the point of use in industry.

Most industries located on municipal water supply systems find the quality of water provided to be satisfactory. If the water quality requirements of an industry are such that water of higher quality than that provided by the municipality is required for specific process use, the industry generally accepts the additional costs involved to produce the higher quality water.

TABLE IWS-1

WATER QUALITY CRITERIA FOR THE BREWING AND SOFT DRINK INDUSTRIES

(Unless otherwise indicated, units are mg/l)

Characteristic	Concentration
Alkalinity ($CaCO_3$)	85
pH, units	(1)
Hardness ($CaCO_3$)	(1)
Chloride (Cl)	250(2)
Sulphate (SO_4)	250(2)
Iron (Fe)	0.3(3)
Manganese (Mn)	0.05
Fluoride (F)	1(3)
Dissolved solids	(1)
Organics: carbon chloroform extract (CCE)	0.15(3)
Coliform bacteria, count/100 ml	(3)
Colour, units	5(4)
Taste, threshold number	(4, 5)
Odour, threshold number	(4, 5)

(1) Controlled by treatment for other constituents.
(2) For brewing, value should not exceed 100 mg/l.
(3) Not greater than OWRC Drinking Water Objectives.
(4) In general, public water supplies are given conventional treatment such as coagulation, filtration and chlorination. Any additional requirement for higher quality, for example, deionized water, is the responsibility of the industry. To ensure low organic content, activated carbon treatment is used by industry.
(5) Zero, not detectable by test.

TABLE IWS-2

WATER QUALITY CRITERIA FOR THE CHEMICAL AND ALLIED PRODUCTS INDUSTRIES*

(Unless otherwise indicated, units are mg/l)

Characteristic	Concentration[1]
Alkalinity (as $CaCO_3$)	150
Iron (Fe)	0.3
Manganese (Mn)	0.1
Calcium (Ca)	50
Magnesium (Mg)	25
Bicarbonate (HCO_3)	250
Sulphate (SO_4)	250
Chloride (Cl)	250
Nitrate (NO_3) as N	10
Hardness (as $CaCO_3$)	250
pH, units	6.5-8.5
Dissolved solids	750
Silica	50
Colour, units	20
Suspended solids	15

* Industries include the manufacture of synthetic rubber, plastics, fertilizers, soap and detergents, organic and inorganic chemicals, etc.

(1) Because of the varying requirements of the many uses in the vast number of chemical industries, more stringent restrictions are placed on several of the above noted characteristics. In some cases, any concentration can be handled, while in others, the raw water is accepted as received provided it meets total solids or other limiting values. The above concentrations are suggested guidelines that should be suitable for the majority of uses in the chemical industry.

TABLE IWS-3

WATER QUALITY CRITERIA FOR COOLING WATER*

(Unless otherwise indicated, units are mg/l)

Characteristic	Concentration
Turbidity	50
Hardness	50
Iron	0.5
Manganese	0.5

- Cooling waters should have appropriate initial temperatures and should not deposit scale, be corrosive or encourage the growth of slimes. Among the constituents of natural water that may prove detrimental to its use for cooling purposes are hardness, suspended solids, dissolved gases, acids, oil and other organic compounds and slime-forming organisms.

TABLE IWS-4

WATER QUALITY CRITERIA FOR THE FOOD PROCESSING INDUSTRY

(Unless otherwise indicated, units are mg/l)

Characteristic	Concentration
Alkalinity ($CaCO_3$)	150
pH, units	6.5-8.5
Hardness ($CaCO_3$)	150
Chloride (Cl)	250
Sulphate (SO_4)	250
Iron (Fe)	0.2
Manganese (Mn)	0.2
Chlorine (Cl)	(1)
Fluoride (F)	1(2)
Silica (SiO_2)	50
Phenol	(3, 4)
Nitrate (NO_3) as N	10(2)
Nitrite (NO_2) as N	(3)
Organics:	
Carbon chloroform extract (CCE)	0.15
Odour, threshold number	(3)
Taste, threshold number	(3)
Turbidity	(6)
Colour, units	5
Dissolved solids	500
Suspended solids	10
Coliform, count/100 ml	(6)
Total bacteria, count/100 ml	(7)

(1) Process waters for food canning are purposely chlorinated to a selected, uniform level. An unchlorinated supply must be available for preparation of canning syrups.

(2) Waters used in the processing and formulation of foods for babies should be low in fluorides concentration. Also, because high nitrate intake is alleged to be involved in infant illnesses, the concentration of nitrates in waters used for processing baby foods should be low.

(3) Zero, not detectable by test.

(4) Because chlorination of food processing waters is a desirable and widespread practice, the phenol content of intake waters must be considered. Phenol and chlorine in water can react to form chlorophenol, which even in trace amounts can impart a medicinal off-flavour to foods.

(5) Maximum permissible concentration may be lower depending on type of substance and its effect on odour and taste.

(6) As required by OWRC Drinking Water Objectives.

(7) The total bacterial count must be considered as a quality requirement for waters used in certain food processing operations. Other than aesthetic considerations, high bacterial concentration in waters coming in contact with frozen foods may significantly increase the count per gram for the food. Waters used to cool heat-sterilized cans or jars of food must be low in total count for bacteria to prevent serious spoilage due to aspiration of organisms through container seams. Chlorination is widely practised to assure low bacterial counts on container cooling waters.

WATER QUALITY CRITERIA FOR THE ELECTROPLATING AND METAL FINISHING INDUSTRIES — IWS-5

Plating-room processes that utilize water include the stripping or pickling operations, cleaning by organic solvents or alkaline solutions, rinsing, and electrochemical plating. For acid stripping or for alkaline cleaning, the quality of water used in the baths is seldom critical, for the added chemicals far outweigh the natural constituents of the water. Hardness of water may be detrimental when soaps or alkaline cleaning agents are used.

For rinsing and for plating, water quality is frequently a major problem. High quality water is of primary importance to assure satisfactory finished work. For decorative plating, water spots and stains may necessitate reworking, wiping, buffing, and other laborious operations. Before the application of any organic corrosion-resistant coating, it is almost a necessity to use demineralized water in the final rinse, in order to achieve adhesion of the coating. A high concentration of dissolved solids is especially detrimental in rinse waters.

In plating baths, iron, aluminum, calcium, magnesium, sodium, potassium, carbonate, bicarbonate, sulphide, sulphite, sulphate, fluoride, chloride, silicate, copper, and lead have been reported to cause difficulties under certain conditions. Considerable evaporation occurs from plating baths and hence the ions present in the make-up water are concentrated to the extent that they are troublesome.

Calcium and magnesium are especially troublesome in plating baths, for they tend to precipitate to form scale on the heated surface or a sludge in the water. There is a probability of these precipitates being included in the electro-deposit, causing pits, porosity, and roughness. Magnesium may also reduce the "throwing power" in chromium baths, but on the other hand, magnesium sulphate is sometimes added to nickel-plating baths to produce softer deposits, to minimize certain types of pitting, and to increase throwing power.

Sodium and potassium are generally not harmful in plating operations, although sodium may cause brittle deposits in nickel baths or reduce the throwing power in chromium solutions. Iron is one of the most troublesome pollutants of many plating operations. In a nickel-sulphate bath, it may cause hazy, streaked, pitted, or brittle deposits; in acid copper solutions, it produces rough deposits; in chromium baths, it reduces the throwing power; in

cadmium cyanide, it causes hazy deposits; in silver cyanide, stained deposits; and in zinc sulphate baths it lowers the plating efficiency and the protective value of the coating.

Among the anions, bicarbonates are detrimental in heated alkaline baths, for they tend to be converted to carbonates and accelerate the precipitation of calcium. Moreover, they buffer the water and require higher dosages of acid or alkali to obtain the desired pH value. Chlorides have been reported to cause rough, modular, iridescent, and crystalline deposits in cadmium, copper, silver, and tin baths respectively. Organic substances reduce chromium, and cause rough, hazy, streaked, coloured, or pitted deposits under various conditions. Colour and turbidity are similarly objectionable.

Abstracted from "Water Quality Criteria", 2nd Edition, State Water Quality Control Board, California, Publication No. 3-A

TABLE IWS-6

WATER QUALITY CRITERIA FOR THE IRON AND STEEL INDUSTRY

(Unless otherwise indicated, units are mg/l)

Characteristic	Quenching, hot rolling, gas cleaning	Cold rolling	Selected rinse waters	
			Softened	Demineralized
Suspended solids	25	10	(2)	(2)
Dissolved solids	(1)	(1)	(1)	(2)
Alkalinity ($CaCO_3$)	(3)	(3)	(3)	(2)
Hardness ($CaCO_3$)	(3)	(3)	100	(2)
pH, units	6.0-9.0	6.0-9.0	6.0-9.0	(3)
Chloride (Cl)	150	150	150	(2)
Dissolved oxygen (O_2)	(4)	(4)	(4)	(4)
Temperature, °F	100	100	100	100
Oil	(1)	(2)	(2)	(2)
Floating material	(1)	(2)	(2)	(2)

(1) Accepted as received if meeting total solids or other limiting values.

(2) Zero, not detectable by test.

(3) Controlled by treatment for other constituents.

(4) Minimum to maintain aerobic conditions.

TABLE IWS-7

WATER QUALITY CRITERIA FOR THE PETROLEUM INDUSTRY

(Unless otherwise indicated, units are mg/l)

Characteristic	Concentration
Silica (SiO_2)	(1)
Iron (Fe)	1
Calcium (Ca)	75
Magnesium (Mg)	25
Bicarbonate (HCO_3)	(1)
Sulphate (SO_4)	(1)
Chloride (Cl)	200
Fluoride (F)	(1)
Nitrate (NO_3) as N	(1)
Dissolved solids	750
Suspended solids	10
Hardness ($CaCO_3$)	350
Noncarbonate hardness ($CaCO_3$)	70
Colour, units	(1)
pH, units	6.0-9.0

(1) Accepted as received if meeting total solids or other limiting values.

TABLE IWS-8

WATER QUALITY CRITERIA FOR THE PULP AND PAPER INDUSTRY

(Unless otherwise indicated, units are mg/l)

		Chemical Pulp and Paper	
Characteristic	Mechanical Pulping	Unbleached	Bleached
Silica (SiO_2)	(1)	50	50
Aluminum (Al)	(1)	(1)	(1)
Iron (Fe)	0.3	1.0	0.1
Manganese (Mn)	0.1	0.1	0.05
Zinc (Zn)	(1)	(1)	(1)
Calcium (Ca)	(1)	20	20
Magnesium (Mg)	(1)	10	10
Sulphate (SO_4)	(1)	(1)	(1)
Chloride (Cl)	500	200	200
Dissolved solids	(1)	(1)	(1)
Suspended solids	(1)	10[(2)]	10[(2)]
Hardness ($CaCO_3$)	(1)	100	100
pH, units	6.0-9.0	6.0-9.0	6.0-9.0
Colour, units	30	30	10
Temperature, °F	(1)	(1)	95

(1) Accepted as received if meeting total solids or other limiting values.

(2) No gritty or colour-producing solids.

TABLE IWS-9

WATER QUALITY CRITERIA FOR THE LEATHER TANNING AND FINISHING INDUSTRY

(Unless otherwise indicated, units are mg/l)

Characteristic	Tanning Processes	General Finishing Processes	Colouring
Alkalinity ($CaCO_3$)	(1)	130	130
pH, units	6.0-8.0	6.0-8.0	6.0-8.0
Hardness ($CaCO_3$)	150	(2)	(3, 4)
Calcium (Ca)	60	(2)	(3, 4)
Chloride (Cl)	250	250	(5)
Sulphate (SO_4)	250	250	(5)
Iron (Fe)	0.3	0.3	0.1
Manganese (Mn)	0.2	0.2	0.01
Organics:			
Carbon chloroform extract (CCE)	(5)	0.2	(3)
Colour, units	5	5	5
Coliform bacteria, count/100 ml	(6)	(6)	(5)
Turbidity	(3)	(3)	(3)

(1) Accepted as received if meeting total solids or other limiting values.
(2) Lime softened.
(3) Zero, not detectable by test.
(4) Demineralized or distilled water.
(5) Concentration not known.
(6) OWRC Drinking Water Objectives.

TABLE IWS-10

WATER QUALITY CRITERIA FOR THE TEXTILE INDUSTRY

(Unless otherwise indicated, units are mg/l)

Characteristic	Sizing Suspension	Scouring	Bleaching	Dyeing
Iron (Fe)	0.3	0.1	0.1	0.1
Manganese (Mn)	0.05	0.01	0.01	0.01
Copper (Cu)	0.05	0.01	0.01	0.01
Dissolved solids	100	100	100	100
Suspended solids	5	5	5	5
Hardness ($CaCO_3$)	25	25	25	25
pH, units:				
Cotton	6.5-10.0	9.0-10.5	2.5-10.5	7.5-10.0
Synthetics	6.5-10.0	3.0-10.5	(1)	6.5-7.5
Wool	6.5-10.0	3.0-5.0	2.5-5.0	3.5-6.0
Colour, units	5	5	5	5

(1) Not applicable.

4 CRITERIA FOR PUBLIC WATER SUPPLIES (PWS)

Criteria are given for public and private supplies from both surface and ground water sources.

Public supplies include water systems operated by municipalities, public utilities, industries, commissions, commercial establishments, etc. where competent operation of the water supply system is provided.

Private supplies include water systems operated by personnel who may not have the necessary technical or mechanical expertise.

PWS-1 Criteria for Public Surface Water Supplies

Since treatment processes exist which can convert any raw water (with a few minor exceptions) to potable water, it is necessary to define a commonly accepted treatment system which can produce a potable water at a reasonable cost. For the purposes of these criteria, such a system has been defined to consist of coagulation, flocculation, sedimentation and rapid sand filtration; the use of chemicals is restricted by definition to the commonly used coagulants and chlorine for disinfection.

Two types of criteria have been established, namely the Permissible Criteria and the Desirable Criteria (Table PWS-1). Waters meeting both of these criteria are acceptable for treatment by the defined treatment process stated above. Waters meeting the Desirable Criteria provide for a greater margin of safety.

It should be borne in mind that the values given under the Permissible Criteria cannot be considered as maximum single sample values. These criteria should not be exceeded over substantial portions of time. If this should occur, then it will become necessary to determine the cause and initiate corrective action. The frequency and variety of sampling should be based on the findings of a comprehensive pollution survey.

TABLE PWS-1

WATER QUALITY CRITERIA FOR PUBLIC SURFACE WATER SUPPLIES

(Unless otherwise indicated, units are mg/l)

Constituent or Characteristic	Permissible Criteria	Desirable Criteria
Physical		
Colour (platinum-cobalt)	75 units	< 5 units
Odour	Readily removable by defined treatment	Absent
Turbidity	— do —	Absent
Temperature	85°F	Pleasant tasting
Inorganic Chemicals		
Ammonia	0.5 (as N)	< 0.01
Arsenic*	0.05	Absent
Barium*	1.0	Absent
Boron*	1.0	Absent
Cadmium*	0.01	Absent
Chloride*	250	< 25
Chromium* (hexavalent)	0.05	Absent
Copper*	1.0	Virtually absent
Dissolved Oxygen	≥ 4 (monthly mean) ≥ 3 (individual sample)	Near saturation
Fluoride*	See footnote (1)	1.0
Hardness*	Acceptable levels will vary with local hydrogeologic conditions and consumer acceptance.	
Iron (filterable)	0.3	Virtually absent
Lead*	0.05	Absent
Manganese* (filterable)	0.05	Absent
Nitrate plus Nitrite*	10 (as N)	Virtually absent
pH range	6.0 - 8.5 units	Least amount of interference with treatment process
Phosphorus* (phosphates)	Not encourage growth of algae or interfere with treatment process	
Selenium*	0.01	Absent
Silver*	0.05	Absent
Sulphate*	250	< 50
Total Dissolved Solids* (filterable residue)	500	< 200
Uranyl Ion*	5	Absent
Zinc*	5	Virtually absent
Organic Chemicals[2]		
Carbon chloroform extract* (CCE)	0.15	< 0.04
Cyanide*	0.20	Absent
Methylene blue active substances*	0.5	Virtually absent
Oil and grease*	Virtually absent	Absent

Table PWS-1 (cont.)

Constituent or Characteristic	Permissible Criteria	Desirable Criteria
Pesticides:		
Aldrin*	0.017	— do —
Chlordane*	0.003	— do —
DDT*	0.042	— do —
Dieldrin*	0.017	— do —
Endrin*	0.001	— do —
Heptachlor*	0.018	— do —
Heptachlor epoxide*	0.018	— do —
Lindane*	0.056	— do —
Methoxychlor*	0.035	— do —
Organic phosphates plus carbamates*	0.1	— do —
Toxaphene*	0.005	— do —
Herbicides:		
2,4-D plus 2,4,5-T, plus 2,4,5-TP*	0.1	— do —
Phenolic Substances*	Virtually absent	— do —
Radioactivity	(pc/l)	(pc/l)
Gross beta*	1,000	< 100
Radium-226*	3	< 1
Strontium-90*	10	< 2
Microbiological (3)		
Coliform organisms (at 35°C)	5,000/100 ml	< 100/100 ml
Fecal coliforms (44.5°C)	500/100 ml	< 10/100 ml
Fecal streptococci (35°C)	50/100 ml	< 1/100 ml
Total Bacteria (20°C)	100,000/100 ml	< 1,000/100 ml
Clostridia (in water) (35°C)	50/100 ml	0/100 ml

* The defined treatment process has little effect on the constituents.

(1)

Annual Avg. of Max. Daily Air Temp. F.	Recommended Limit for Fluoride mg/l
50.0 to 53.7	1.7
53.8 to 58.3	1.5
58.4 to 63.8	1.3

(2) Organic chemicals should not be present in concentrations as to cause adverse tastes and odours which cannot be removed by the defined treatment and/or by chlorination only.

(3) A monthly geometric mean of the results of raw water samples collected on a weekly basis (minimum of one sample per week) should be less than the numbers given under the Permissible Criteria column. These figures do not imply a relationship between bacterial groups.

PWS-2 Criteria for Public Ground Water Supplies

With the exception of dissolved oxygen, fluorides and microbiological criteria, the water quality criteria for surface water apply to ground water supplies.

For fluorides, hydrogen sulphide and pollution indicator organisms, the following apply to ground water supplies:

	Permissible Criteria	Desirable Criteria
	(Unless otherwise indicated, units are mg/l)	
Fluoride	2.4	1.0
Hydrogen Sulphide	0.1	Absent
Pollution Indicator Organisms	Coliform and other pollution indicator organisms should be virtually absent from all ground water supplies.	

It is considered desirable to provide the maximum of treatment — chlorination — for all ground water supplies. This measure ensures that nuisance organisms which exist in virtually all waters do not get the opportunity to develop a foothold in a water distribution system and thereby create objectionable conditions.

PWS-3 Criteria for Private Water Supplies

The raw water available to private supplies such as individual dwellings, cottages, farms, etc , must be of such quality that it can be used in the raw state or be made acceptable for use with a minimum of treatment limited to disinfection, filtration and/or softening. Economic considerations and lack of technical/mechanical expertise will prohibit the use of raw water supplies that require extensive treatment.

Some surface supplies have turbidities, colour and other undesirable constituents in excess of what can be used effectively in home or farm operations. Some ground water supplies (wells and springs) harbour objectionable gases, nuisance bacteria, in addition to having high concentrations of iron and being highly mineralized. The initial approach in establishing a private water supply should be to explore the ground water potential from the aspects of both quality and quantity. In many instances, deficiencies in ground water quality can be offset at a relatively low cost compared to that for surface waters.

Criteria for private water supplies are identical to the surface water criteria for public water supplies, with the exception of fluorides, hydrogen sulphide, physical and microbiological characteristics. For fluorides and hydrogen sulphide, the applicable criteria appear in Section PWS-2.

Physical Criteria:

The water supply should be substantially free from substances offensive to sight, taste or smell. Threshold odour values in excess of three units are generally considered objectionable.

Colour in the water supply should not exceed 15 units (platinum-cobalt scale).

Turbidity should be less than five units. Turbidities of up to 20 units may be removed relatively easily by sand or diatomaceous earth filters.

Microbiological Criteria:

Microorganisms	Permissible Criteria		Desirable Criteria
	Chlorination only	Chlorination & Filtration	No Treatment
Coliforms (35°C)	100/100 ml	400/100 ml	0/100 ml
Fecal Coliforms (44.5°C)	10/100 ml	40/100 ml	0/100 ml
Enterococci (35°C)	1/100 ml	4/100 ml	0/100 ml
Total Bacteria (20°C)	1000/100 ml	4000/100 ml	10/100 ml
Clostridia (in water) (35°C)	0/100 ml	4/100 ml	0/100 ml

Raw water samples should be collected at least monthly. The Geometric Mean of sample results should not exceed the values given in the table above.

5 CRITERIA OF WATER QUALITY FOR AESTHETICS AND RECREATION (A & R)

All surface waters should be capable of supporting life forms of aesthetic value. The positive aesthetic and recreational values of water should be attained through continuous enhancement of water quality. Surface waters should be of such quality as to provide for the enjoyment of recreational activities such as hunting and fishing which are based on the utilization or consumption of fish, waterfowl and other forms of life.

The aesthetic and recreational values of unique or outstanding waters should be recognized and protected by development of appropriate water quality standards for each individual case. To retain or establish unspoiled wilderness values, it may be necessary to control access by mechanized methods of transportation.

General criteria for recreation and aesthetic use and specific criteria for total body contact recreation follow:

A & R-1 General Criteria for Recreation and Aesthetics

Surface waters should be free of substances attributable to discharge of waste or land drainage which may impair aesthetic or recreational use, as follows:

(1) Materials that will settle to form objectionable deposits.

(2) Floating debris, oil, scum and other matter.

(3) Substances producing objectionable colour, odour, taste or turbidity.

(4) Materials, including radionuclides, in concentrations or combinations which are toxic or which produce undesirable physiological responses in humans, fish and other life and plants.

(5) Substances, including nutrients, and conditions, including temperature, or combinations thereof in a degree or concentration which produces undesirable types or abundance of aquatic life.

A & R-2 Criteria for Total Body Contact Recreation

Surface waters for total body contact recreational use should be free of substances attributable to discharge of waste or land drainage as follows:

(1) Materials which will cause the pH to change beyond the range 6.5-8.3.

(2) Materials which will obscure visibility in the water. In designated swimming and diving areas, clarity should be such that a Secchi Disc on the bottom is visible from the surface.

(3) Conditions which will cause the water temperature to exceed 85°F.

(4) Microbiological Criteria
Water used for body contact recreational activities should be free from pathogens including any bacteria, fungi or viruses that may produce enteric disorders or eye, ear, nose, throat and skin infections. Where ingestion is probable, recreational waters can be considered impaired when the coliform, fecal coliform, and/or enterococcus geometric mean density exceeds 1000, 100 and/or 20 per 100 ml respectively, in a series of at least ten samples per month, including samples collected during weekend periods.

If these criteria are exceeded, it will become necessary to determine the cause and initiate corrective action.

When evaluating a given area of water for recreational use, the appropriate numbers of samples, and the choice of tests to be performed should be determined by consultation between sampler and analyst, prior to sampling. An effort should be made to increase utilization of the fecal coliform and enterococcus tests since these presently appear to be the more relevant guides to the bacterial quality of bathing waters.

GLOSSARY OF TERMS

Bioassay	—	A controlled laboratory procedure which subjects live aquatic organisms to various environmental stresses.
Effluent Requirements	—	Numerical or verbal descriptions of the quality of a waste or drainage effluent at the point of discharge to a receiving water body, land disposal site or waste disposal well.
Eutrophication	—	The increase in the nutrient content of the natural waters of a lake or other body of water.
Geometric Mean	—	The nth root of the product of n observations. The equation for the geometric mean (G_x) can be expressed as: $G_x = \sqrt[n]{X_1 . X_2 . X_3 . \ldots \ldots \ldots . X_n}$ or $G_x = \text{antilog}\left(\frac{\log X_1 + \log X_2 + \ldots . \log X_n}{n}\right)$
Land Drainage	—	Water that has drained from the land surface naturally or through man-made drainage systems.
Milligrams per Litre (mg/l)	—	A unit of measure expressing the concentration of a substance in a solution.
Milligram equivalents per litre (mg. eq/l)	—	A unit indicating the chemical equivalence of ions; derived by dividing the concentration of an ion in milligrams per litre by the combining weight of that ion. Note: combining weight $= \frac{\text{atomic or molecular weight of ion}}{\text{ionic charge}}$
Oligotrophic	—	Waters with a small supply of nutrients and hence a small organic production; usually having abundant dissolved oxygen at all depths.
Photosnythetic (adj.)	—	Relating to the process by which the chlorophyl-bearing cells of green plants convert carbon dioxide (CO_2) and water (H_2O) into sugar ($C_6H_{12}O_6$) and oxygen (O_2) in the presence of light.
Raw Water	—	Surface or ground water, prior to treatment.
Waste	—	Liquid carrying unwanted materials or compounds resulting from human activities or enterprises to a point of discharge. The mixture may or may not have received treatment.
Water Quality Criteria	—	Numerical or verbal descriptions of the quality of water required for particular uses.
Water Quality Standards	—	Numerical or verbal descriptions of the quality of water required for a variety of uses in a given drainage system.

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